URBAN WILDLAND INTERFACE BUILDING TEST STANDARDS

12-7A-1

FIRE RESISTIVE STANDARDS FOR EXTERIOR WALL SIDING AND SHEATHING

STATE FIRE MARSHAL

(a) Application. *The minimum design, construction and performance standards set forth herein for exterior wall siding and sheathing are those deemed necessary to establish conformance to the provisions of these regulations. Materials and assemblies that meet the performance criteria of this standard are acceptable for use in Very High Fire Hazard Zones as defined in California Building Code, Chapter 7A.*

(b) Scope. *This standard determines the performance of exterior walls of structures when exposed to direct flames.*

(c) Referenced documents.

1. *ASTM D4444. Standard Test Methods for Use and Calibration of Hand-Held Moisture Meters*
2. *ASTM D 2898. Standard Test Methods for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing*
3. *California Building Code, Chapter 7A*

(d) Definitions

1. ***Cladding****. Any material that covers an interior or exterior wall*
2. ***Sheathing****. The outside covering used over the wall framework and is nailed directly to the wall framing members*.

(e) Equipment

1. ***Burner.*** *A 4 x 39 in. (100 x 1000 mm) propane diffusion burner shall be used.*
2. ***Infrared temperature analyzer*** *(optional). Intended for monitoring the temperature change of the inside of the sheathing material.*
3. ***Moisture meter****. For measurement of moisture content of framing.*

(f) Materials

1. ***Cladding****. Material selected for the test*
2. ***Sheathing*** *(optional). 4- x 8-ft (1.2- x 2.4- m) sheet*
3. ***Framing****. 2 x 4 studs*

(g) Test system preparation (Figure 1).

1. ***Wall Module.*** *The module shall be designed to permit rapid installation and removal of wall assemblies and have two adjustable non-combustible sidewalls, and a non-combustible simulated soffit. The module shall permit insertion of a prefabricated 4 x 8 ft (1.2 x 2.4 m) wall section.*
2. ***Framing****. Frame the wall assembly with 2 x 4 studs, typically 16 in. (410 mm) on center.*
3. ***Moisture content****. Measure the moisture content of the wooden members of the assembly using a moisture meter (ASTM D4444)*

4. ***Sheathing**. Add sheathing material (optional). If sheathing is used, tests must be run on nominal 0.5-in (12 mm) oriented standboard of Exposure 1 rating. Any other sheathing may be run, but must be reported. The sheathing must have one seam on a selected stud with a 0.125-in. (3 mm) gap.*
5. ***Cladding**. Attach the chosen cladding according to the cladding manufacturer's directions. All potential cladding joints that may be present in a typical wall must be incorporated into the assembly.*
6. ***Other materials**. Other components of the wall assembly, such as building felt and sheathing, are chosen to meet the manufacturer's specifications and/or local building codes. Cavity insulation is not to be used.*
7. ***Sealing**. Seal the top and side edges of the installed wall with ceramic wool or comparable material to prevent flame penetration at the edges.*
8. ***Finish**. The wall should be finished in a manner appropriate for exterior exposure as specified by the manufacturer.*

(h) Pretest Weathering (optional).

1. ***Number of test assemblies.** Prepare six assemblies of which three shall be randomly selected for the weathering exposure. The remaining three assemblies shall be tested as unweathered controls.*
2. ***Preparation.** The back of the wall assembly must be protected from water penetration by stapling or taping a 4 x 8 ft (1.2 x 2.4 m) sheet of polyethylene film to the outside of the framing members (the side opposite the cladding) to protect the interior of the wall cavity from being wetted by overspray.*
4. ***Weathering.** Subject the assembly to the 12-week wetting-drying weathering exposure defined in ASTM D 2898, Method A, with the following modifications:*
   ***i.** The assembly shall be mounted vertically.*
   ***ii.** The heating cycle shall consist of air heated at 125 ± 5°F (50 ± 2°C) impinging on the wall at 10 mph (17 km/h or 4.5 m/s).*
   ***iii.** An ultraviolet exposure shall be used during the weathering exposure, with the lamps activated during the 72-h drying cycles. Installation and exposure details regarding the sunlamps shall be as described in ASTM D 2898, but shall be modified for a sample having a vertical orientation.*
   ***iv.** The polyethylene film shall be removed after weathering is completed.*
4. ***Conditioning.** Prior to testing, the weathered wall assemblies shall be stored for at least 2 wk indoors with good air circulation at temperatures between 60 and 90°F (16 to 32°C) to allow excess moisture to evaporate.*

(i) Conduct of Tests.

1. ***Airflow.** The wall test shall be conducted under conditions of ambient airflow.*
2. ***Number of tests**. Conduct the tests on three replicate wall assemblies (six for weathered performance).*
3. ***Burner output verification.** Without the wall assembly in place, adjust the burner for 150 ± 8 kW output. Extinguish the burner.*
4. ***Burner configuration**. Center the burner relative to the width of the cladding-wall assembly and 0.75 in. (20 mm) from the wall. The distance from the floor to the top of the burner shall be 12 in. (300 mm).*
5. ***Procedure***
   i) Ignite the burner, controlling for constant 150 ± 8 kW output.
   ii) Continue the exposure until flame penetration of the cladding-wall assembly occurs, or for a 10-min period.
   iii) If penetration does not occur, continue the test for an additional 60 min or until all combustion has ceased. An infrared thermometer has been found to be useful to detect the increase of temperature on the back side of the sheathing and an aid to identify the areas of potential combustion.
6. ***Observations.** Note the time, location, and nature of flame penetration*

(j) Report. *The report shall include a description of the wall cladding, sheathing material, details of the construction of the subassembly, details of the cladding installation, moisture content of the framing, whether the weathering test was conducted, and where flame penetration of the wall occurred. Provide details on the time and reasons for early termination of the test.*

(k) Conditions of Acceptance. *Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.*

1. Absence of flame penetration through the wall assembly at any time.
2. Absence of evidence of glowing combustion on the interior surface of the assembly at the end of the 70-min test.

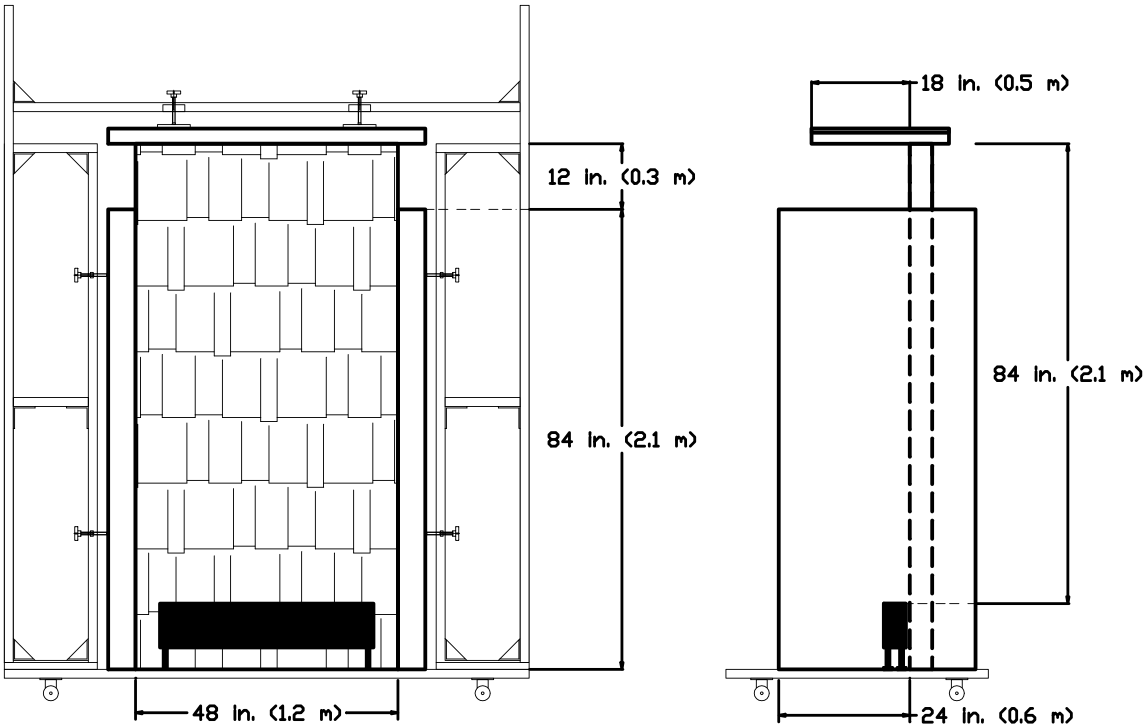

Figure 1. Exterior Wall Test Assembly

COMMENTARY: EXTERIOR WALLS

Purpose. This Commentary is to provide the background and rationale for the Standard. The work that led to this Standard was funded by the California Office of Emergency Services through the Office of the State Fire Marshal, and was provided as FEMA mitigation funds following the 1993 Southern California firestorm. Under the administration of OSFM, the University of California Forest Products Laboratory (UCFPL) developed fire test protocols for Urban-Wildland Interface (UWI) fire in consultation with fire researchers throughout the world and with fire authorities in California.

The research by UCFPL started in 1995; at the completion, after about four years, the work was reviewed by a committee of California fire authorities who prepared a report intended to lead to model building codes. However, the movement to code was delayed until 2004, when the California Legislature (through AB1216) directed OSFM to complete the code work by 1 January 2005. Under the administration of OSFM, the test protocols developed by UCFPL were written into Standards language.

Included in the Commentary are explanations of the development of test protocols and results from the preliminary tests at UCFPL. The tests were not intended to "certify" materials and/or assemblies, but to provide guidance in the development of the test protocols and for the "conditions of acceptance." Also included are discussions of issues that were not addressed in the protocols, but which should be explored to amend the Standards to better address UWI fire issues.

Issues in UWI fire.

Exterior walls are exposed to convective and radiant heat from an approaching wildfire and to ignition of flammable materials (plants, trash, a deck or shed, etc.) that might be adjacent to a building. However, the preponderance of evidence is that convective and radiant heat are minor factors in UWI fire impact on exterior walls.

There are two major concerns for walls having combustible cladding:

1. Ignition directly (radiation, convection, flame contact) or indirectly (combustion of materials near the base of the wall), followed by penetration into the wall cavity (directly or indirectly through the wall assembly, or through seams) and then into the building.

2. After ignition, vertical flamespread to windows, eaves, or upper ancillary structures, and subsequent penetration of the structure.

For non-combustible cladding, the major concern is conductive heat transfer through the wall cavity that can ignite studs or other wall cavity materials. Also, for materials having seams, there is a possibility of penetration via these openings.

Wall assembly.

The wall assembly test module (Figure 1 in the Standard) permits rapid installation and removal of 4- × 8-ft (1.2- × 2.4-m) wall assemblies, and is designed to prevent penetration of fire at the panel edges. The side enclosure and soffit provide shielding from ambient air currents and permit normal eddy currents to occur, respectively. The wall assembly did not have insulation or sheathing on the back side in order to permit visual and infrared observation of combustion or temperature build-up on the back side.

Development of the Test Protocol.

Since ignition by ornamental plants (or equivalent combustibles) is the most probable source of flame impingement of walls, a number of tests were run to determine the likely intensity and duration of exposure from small to medium size plants. From these tests (and other sources of research), the decision was to use a 150-kW line burner for a 10-min exposure. The exposure time was determined by field reports on the maximum length of time that a structure would be subjected to this level of intensity.

Tests.

Materials. Tables 1 and 2 give the cladding and sheathing materials used in the preliminary tests. All sheathing was 0.5-in (12-mm nominal thickness. These materials were selected as representative of use on structures in California. Because of limitations in equipment and scope, it was not possible to test stucco cladding, but wood fiber-cement materials also have a conductive mode of heat transfer.

Assemblies. All wall assemblies were framed with Douglas-fir 2 x 4s, 16 in. (410 mm) on center.

For cladding, seams were included that would representative of a typical wall. For the horizontal lap cladding products, the patterns included plain bevel, rabbetted bevel, and shiplap. The vertical joints in panelized cladding products were either shiplap or simple butt-joints. Sheathing, when used, was either OSB or plywood, and with and without a butt joint.

Test procedure. The 10-min 150 kW exposure was used for the cladding-sheathing combinations, followed by an additional 60-min observation to detect any smoldering combustion (Table 1). The use of infrared photography of the back of the test wall was used to reveal development of increasing temperatures or persisting hot spots. Other tests (Table 2 and 3) were run on solely cladding or sheathing, where the burner was left on until failure to determine the weak points in various materials. Since no sheathing was used in cladding tests, shingles, which are nailed to sheathing, could not be included.

Results. Most of the cladding-sheathing assemblies (Table 1) had acceptable performance. However, the hardboard cladding failed because it burned vigorously and warped away from the sheathing, exposing it to flames. Likewise, the fire-retardant treated redcedar shingles quickly deformed and lifted off the sheathing. This test was terminated early (13 min) because of the acrid smoke, but since combustion was sustained, it was estimated that this wall would have burned through within 20 min.

For the cladding-only tests (Table 2), flame penetration occurred at joints for “combustible” cladding. The exception was wood fiber-cement cladding, for which in one case intermittent flame penetration was first seen at a crack in the panel, while in another, conducted heat ignited a stud behind the cladding. Flammability was clearly a major factor in cladding performance, as can be seen in the dramatic improvement in western redcedar cladding when it was fire-retardant treated with a chemical that had intumescent properties. It should be noted that the overlap was also much greater (1.5 vs 0.5 in.; 37 vs 12 mm) with this product, adding further protection against vertical flame penetration.

Table 3 shows the results for the sheathing-only tests to compare OSB and plywood. In both cases (with and without joints) the OSB failed in about 80% of the time of plywood. The relative effect of joint vs no-joint was slightly greater—about 75% less time to failure with joints in both materials. The joints had openings of 3 mm in compliance with manufacturers' recommendations.

Comments. Since the tests were conducted to obtain data on a wide range of materials and combinations of materials, only single tests were run for each assembly. The nature of the cladding joints had a substantial effect on relative performance. Most vulnerable was the plain bevel, while rabbetted and shiplap joints were increasingly resistant to flame-through. Based on these results, tongue-in-groove cladding, although not tested, should also perform well. The other important factor in fire resistance of cladding was the material itself. When the joint type was similar, wood composites such as hardboard and OSB were more vulnerable to fire penetration than solid wood and wood fiber-cement products. The length of the recommended observation period (60 min) after the 10-min burner exposure was found to be important to assure the detection of smoldering combustion, such as occurred in the finger-jointed redwood with OSB sheathing (Table 1). In UWI fires, the persistence of smothering combustion could lead to loss of structures long after they might be considered safe.

The information in Table 2 is applicable to many earlier forms of building construction where panel sheathing was either not used or code requirements were less stringent than today. Cladding without sheathing was unable to pass the 70-min (total) test; four even failed during the 10-min burner exposure. Several of the cladding materials that failed (Western redcedar FRT, finger-jointed redwood with plywood, L-P OSB, and both Hardie products) were able to pass when backed with sheathing (Table 2). The wood-fiber cement cladding performance shows that sheathing can play a very important insulation role to prevent ignition of studs.

The "conventional wisdom" has been that ignition of the cladding leads to loss of the structure, however, it was apparent that combustible cladding over combustible sheathing can withstand a substantial fire exposure. However, if the combustible cladding causes vertical flamespread to windows or eaves, it is quite possible that this could lead to failure indirectly, whereas non-combustible cladding would not promote this scenario.

Conditions of Acceptance. Based on the tests, the acceptance criteria listed in Standard SFM-1 were considered appropriate.

Table 1. Cladding over sheathing tests

Product description	Joint type	Sheathing	Flame-through (min)	Notes
Western redcedar shingles (FRT)	Multiple joints	OSB	20 (est.)	Flaming sustained after 10 min; term at 13 min (irritating fumes)
Western redcedar, FRT nominal 6 in. pattern	Plain bevel horizontal lap	OSB	None	
Western redcedar, FRT nominal 6 in. pattern	Plain bevel horizontal lap	Plywood (CDX)	None	
Collins Pine Hardboard	Rabbetted bevel horizontal lap	OSB	22	Penetration at lap joint & thru sheathing joint
Collins Pine Hardboard	Rabbetted bevel horizontal lap	Plywood (CDX)	22	Penetration at lap joint & thru sheathing joint
Redwood, finger-jointed nominal 8 in. pattern	Rabbetted bevel horizontal lap	OSB	65	Glowing combustion continued until sheathing penetrated
Redwood, finger-jointed, nominal 8 in. pattern	Rabbetted bevel horizontal lap	Plywood (CDX)	None	
Louisiana-Pacific OSB	Rabbetted bevel horizontal lap	OSB	None	
James Hardie wood fiber-cement (HardiePlank)	Plain bevel horizontal lap	OSB	None	
James Hardie wood fiber-cement (HardiePlank)	Plain bevel horizontal lap	Plywood (CDX)	None	
James Hardie wood fiber-cement (HardiePanel)	Vertical butt joint, panel	OSB	None	
James Hardie wood fiber-cement (HardiePanel)	Vertical butt joint, panel	Plywood (CDX)	None	

Table 2. Cladding-only tests

Product description	Joint type	Flame-through (min:s)	Notes
Western redcedar	Plain bevel horizontal lap	1:15	Failed at lap joint
Western redcedar, FRT nominal 6 in. pattern	Plain bevel horizontal lap	18:45	Failed at lap joint
Redwood, finger-jointed nominal 8 in. pattern	Rabbetted bevel horizontal lap	5:58	Failed at lap joint
Redwood nominal 6 in. pattern	Horizontal shiplap	21:18	Failed at lap joint
Laminated veneer lumber	Horizontal shiplap	15:40	Failed at lap joint
Plywood (T1-11)	Vertical shiplap, panel	22:15	Failed at lap joint
Louisiana-Pacific OSB	Rabbetted bevel horizontal lap	2:38	Failed at lap joint
Collins Pine Hardboard	Rabbetted bevel horizontal lap	3:20	Failed at lap joint
James Hardie wood fiber-cement (HardiePlank)	Plain bevel horizontal lap	21:35	Stud ignited
James Hardie wood fiber-cement (HardiePanel)	Vertical butt joint, panel	29:00	Failed at crack in panel

Table 3. Sheathing-only tests

Product description	Joint type	Flame-through (min:s)	Notes
Oriented strandboard	Vertical butt joint (on stud)	12:15	Failed at joint
Plywood (CDX)	Vertical butt joint (on stud)	15:20	Failed at joint
Oriented strandboard	No joint	16:30	Failed at stud
Plywood (CDX)	No joint	20:15	Failed at stud